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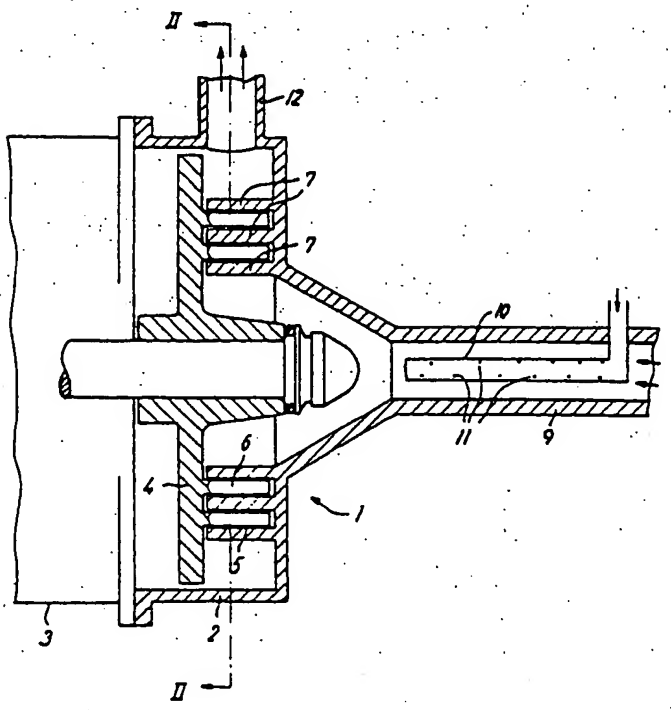
(54) Title: PROCESS FOR PRODUCING A SOLID WATER-IN-OIL EMULSION AND AN APPARATUS FOR CARRYING OUT THE PROCESS

(57) Abstract

A water-in-oil emulsion, such as butter or margarine, having a comparatively low fat content is produced by emulsifying an aqueous component which is buttermilk, skim milk or water, in a fat containing component at a temperature at which the major portion of the fatty substance is in a crystalline state. The emulsification is effected by firstly injecting the aqueous component at several spots spaced apart into a flow of the fat containing component, following which the flow is subjected to a mixing operation particularly exerting displacing and shearing forces. Temperature is controlled to maintain the crystalline state of the fatty substance. An apparatus for carrying out the process includes a pipe (10) having multiple perforations (11) for the injection of the aqueous component into the fat containing component, mounted in the supply conduit (9) of a mixing apparatus (1).



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Process for producing a solid water-in-oil emulsion and an apparatus for carrying out the process.

The invention relates to a process for producing a solid water-in-oil emulsion, such as butter or margarine, having a water content exceeding 30%, from an aqueous component and a lipid component, and a plant suited for carrying out the process.

Among solid water-in-oil emulsions a particular interest attaches to butter and margarine because vast quantities are consumed of these products. The present invention is therefore explained in the following in connection with its being utilized in the production of butter and margarine products, but the invention may also be exploited with respect to the preparation of other products to be used in the food industry or as technical products.

In the production of butter, whether this is done by traditional churning of cream or by making use of a butter machine in which the butter is formed by the whipping of cream, the butter is obtained with a water content ranging from 12 to 23% by weight, typically with a water content of 16% to 17%, and in practice it has not been possible to alter the butter forming process proper so as to thereby directly obtain stable products with a water content greater than 23%. Conventional butter is typically marketed with a fat content of 82% and a water content of about 16% while the remainder, approximately 2%, consists of salt and proteins. Similar proportions between fat and water exist in conventional margarine.

In view of the increasing requirement in developed countries for a low-rated fat content in diet and in order to comply with the wish many consumers have to reduce the consumption of calories there is a need for butter and margarine with a lower fat content than is

conventional.

The most obvious manner of reducing the fat content in this type of products is obviously to increase the water content in the products.

Various processes have been developed for this purpose.

It applies to most of them that an aqueous component is emulsified in a lipid component at a temperature at which the latter is in a molten state, emulsifiers being added, preferably monoglycerides and the like, together with other additives in order to obtain an emulsion which after cooling to a state of complete or partial crystallization of the lipid component constitutes a product to be used in the same manner as conventional butter or margarine, but which has a considerably reduced content of fat. An example of such a process according to which the aqueous component is produced with a particularly high content of milk proteins is disclosed in published DK patent application No. 3895/75.

Such processes in which the fatty substance is being melted during the emulsifying process involve, however, the risk of processing complications because the emulsion due to the presence of larger quantities of water may change from an water-in-oil emulsion to an oil-in-water emulsion, and particularly with respect to the production of butter products it is, for commercial reasons, not desired to make use of emulsifiers not naturally present in butter.

EP patent application No. 00 76 548 deals with a process in which an oil-in-water-in-oil emulsion is prepared by inversion of a so-called bimodal oil-in-water emulsion under conditions causing coalescence and crystallization of the larger oil droplets. However, also under these conditions the inverting process gives rise to considerable operational problems and the pre-

ceding preparation of the bimodal oil-in-water emulsion appears to be complicated, and due to its particular requirements as to the droplet size it seems to be less suited for industrial production, in particular as regards dairy production of butter products.

EP patent applications Nos 00 98 663 and 00 98 664 relate to processes in which a churning process is effected so that the resulting product has substantially the same water content as the oil-in-water emulsion used as the starting material. This is achieved by carrying out the churning at a temperature at which the fatty phase is completely or partially crystallized. Moreover, the use of emulsifiers appears to be indispensable in order to achieve the desired result. The product obtained by said two EP patent applications consists, however, of a network of aggregated fat as well as encapsulated and free aqueous phase and, therefore, it has a minor resemblance to commercial butter and margarine products than desired. Furthermore, the presence of a large proportion of free aqueous phase that is not encapsulated in the fatty phase causes that the keeping qualities of the product are comparatively poor because the product is particularly prone to attacks from microorganisms and drying.

EP patent application No. 0 279 498 relates to an edible plastified dispersion containing less than 35% fat constituting the continuous phase. Also this product is produced by inversion of an oil-in-water emulsion and from the information in the description and claims of the application it can be concluded that the product is only obtainable by the incorporation of emulsifiers, such a monoglycerides which as mentioned above might be undesirable.

GB patent No. 1 525 315 deals with a process for the production of butter and margarine products in

which an aqueous component with a viscosity of from 2000 to 20,000 centipoises is emulsified with the lipid component by a mixing operation thereof at a temperature at which the fatty substance of the lipid component is neither in a crystalline state nor in a molten state. It is stated that if the temperature is so low that the fats are partially crystallized, the obtained product has a sandy or curdled, unpleasant character, while a too high temperature results in the formation of an oil-in-water emulsion.

The requirement for a viscosity of the aqueous component between 2000 and 20 000 centipoises puts certain limits to this prior process, in particular if the viscosity, as desired, is to be obtained without the addition of substances that are not present in corresponding conventional products.

If, in connection with the production of a spread product with a low fat content, an aqueous component is used whose viscosity has been brought to the desired value by the addition of casein and/or caseinate, it is necessary that the pH-value of the aqueous phase as well as its salt content are greater than the standards generally desired. A pH-value in the range of 7 or more is thus required to obtain the necessary viscosity increasing effect of the caseinate, while it is desirable to make use of pH-values in the range from 5 to 7 in respect of the keeping qualities and flavour of the final product. The necessary amount of salt is so large that the resulting product cannot be marketed as "unsalted". This is disadvantageous all the time an "unsalted" product actually appeal to the same group of consumers who prefer butter or margarine having a low fat content rather than corresponding conventional products.

In a paper of D.H. Bullock et al "Continuous Manufacture of a Low-Fat Dairy Spread Having a Water-

in-Fat Emulsion", Journal of Dairy Science, Vol. 54, No. 12, (1971) it is described that an emulsion is prepared by incorporating an aqueous phase into the fatty phase while the latter being crystalline. In said paper a stepwise injection of the aqueous phase combined with intermediate emulsifying processes is described, and further recycling of a substantial part of the product is used. In the final part of the paper it is mentioned as a theoretical possibility that it might be possible to disperse the aqueous phase sufficiently in the fatty phase without using recycling. However, the product obtained by the process described in the paper apparently necessarily contained such high proportion of calcium-reduced skimmilk powder that it can hardly be termed butter.

In published Danish Patent Application No. 5579/89 (APV Pasilac ApS) is described that low-fat butter can be obtained by a process in which an aqueous solution of lactic acid concentrate is added to the butter during or before kneading thereof followed by an addition of an aqueous milk protein solution while the butter passes through a mixing zone. Apparently, this process does not necessitate a recycling of the product, but the separate introduction of lactic acid and the aqueous lactic protein solution makes the process operational complicated and put certain limitations as to the possibility of obtaining a "natural" product.

It has now turned out that contrary to what might be expected on the background of the disclosure of the above cited references, it is possible to obtain very satisfactory results by a process for producing a solid water-in-oil emulsion, such as butter or margarine, having a water content exceeding 30%, from an aqueous component and a lipid component, in which said lipid component is passed once through a mixing zone, comprising distributing by injection at several sites

mutually spaced apart upstream of said mixing zone into a flow of the lipid component at a temperature at which a substantial portion of the fatty substance of the lipid component is in a crystalline state, the aqueous component at a temperature not exceeding the temperature which would cause said portion of the fatty substance of the lipid component that is in a crystalline state to leave this state, following which the flow of the lipid component, into which the aqueous component has been injected, is subjected to an intensive mixing under conditions particularly involving displacing and shearing forces, which process is characterized in using as the aqueous component buttermilk, skimmilk or water without the addition of emulsifiers or lactic acid and in taking provisions that the temperature of the emulsion by the mixing does not rise to such a temperature at which the fatty substance would leave the crystalline state.

The invention is based inter alia on the recognition that the aqueous component can be dispersed sufficiently finely in the solid, partly crystalline lipid component so as to obtain a stable solid emulsion without using emulsifiers or viscosity increasing agents, provided the above defined operational conditions are fulfilled.

The first step of the process, injection of the aqueous component into the lipid component, has turned out to be decisive of the result, in that it is not possible by the intensive mixing operation to obtain a distribution of the aqueous component if this has not previously been encapsulated in small cavities in the lipid component.

It is not the intention to delimit the process according to the invention by means of theoretical explanations of the important feature that the process does not necessitate emulsifiers or viscosity increas-

ing agents, but it is supposed that the high viscosity of the fat of the lipid component at the practised temperatures effectively impedes mutual contact between the small droplets of the aqueous component while being distributed in the lipid component and afterwards.

The aqueous component is preferably distributed so extensively in the lipid component by the intensive mixing operation that the individual droplets thereof have a diameter typically ranging between 5µ and 10µ, corresponding to a typical droplet size of the aqueous phase in conventional butter.

The term lipid component is in this context used as including both pure fatty substances, such as butter fat or other animal or vegetable, possibly hydrogenated fatty substances and fats having a disperse aqueous phase, such as conventional butter or margarine. The fatty substance of the lipid component may typically include a mixture of fats solid and liquid at usual temperatures of storage and usage.

The preferred lipid component is butter having a water content in the range of 12 to 23% by weight, since this is the water content with which butter is ordinarily obtained and since the process according to the invention has been tested primarily with such a starting material.

By using a lipid component which is butter, the crystalline state of which to some degree depends on the seasons, it has turned out that the process generally may be carried out with a favourable result, provided that prior to the injection of the aqueous component into the lipid component and the subsequent intensive mixing operation the temperature of both components be in the range from 10 to 20°C.

It is preferred that the temperature of the butter used as the lipid component is at approximately 15°C and the temperature of the aqueous component a

little lower, at approximately 13°C, in order to compensate for generation of heat during the mixing operation. The butter may thus be used at a temperature at which it is obtained directly from a butter machine or churn.

The circumstance that the process according to the invention does not necessitate any adjuvants in the form of emulsifiers or viscosity increasing agents appears from the fact that by using buttermilk without adjuvants a stable butter product with 44% by weight of fat has been obtained. The viscosity of the buttermilk used was measured to only 15 centipoises at 10°C.

Both in the production of butter and margarine products buttermilk without any additions is preferred as the aqueous component.

The terms buttermilk and skimmilk as used herein comprises not only the native product but also products made by reconstitution using water and buttermilk powder and/or skimmilk powder in various ratios.

In contrast to what would be expected on the background of the disclosure of the above referenced GB patent, the process according to the invention provides for obtaining a product which in an organoleptical sense is completely satisfactory and has a great resemblance to conventional butter or margarine products.

The invention further relates to an apparatus for carrying out the process, said apparatus comprising an intensive mixer in which the material to be processed is passed through slots in closely adjacent walls having a high mutual velocity difference in a direction transverse to the direction of the slots, and a supply conduit to the mixer for a flow of lipid component, the fat of which substantially occurs in a crystalline state, and mounted coaxilly within the supply conduit at least one pipe provided with

perforations said pipe being connected with a source for aqueous component for injecting the aqueous component into various spots spaced apart in the flow of lipid component during its flowing through the supply conduit.

The pipe provided with perforations and mounted coaxially within the supply conduit, enables an even distribution into the flow of lipid component and at the same time does not hamper the flowing of said liquid component through the supply conduit.

Mixers which in particular exert an action of the desired type are the ones in which the material to be processed flows through slots in closely adjacent walls having a high mutual velocity difference in a direction transverse to the direction of the slots. An example of an embodiment of such a mixing apparatus will be described in the following.

The invention will be explained in detail with reference to the drawings, in which

Fig. 1 very schematically and partially in cross-section and in a somewhat reduced scale illustrates an embodiment of an apparatus according to the invention, and

Fig. 2 is a schematical cross-section through the apparatus illustrated in Fig. 1, as shown in line II-II in Fig. 1.

Fig. 1 illustrates an intensive mixer 1 with a housing 2 mounted on an electric motor 3 on the drive shaft on which a rotor 4 is secured.

As it will more clearly appear from Fig. 2, said rotor includes a disc carrying cylindrical coaxial walls 5. The illustrated embodiment has two such cylindrical walls with a somewhat different diameter. Slots 6 are provided in both of said walls by drilling in the axial direction. As it appears from Fig. 2, this technique provides for obtaining very sharp-

edged slots, thereby improving the function of the apparatus.

The illustrated embodiment includes a stator member formed as an integral part of the housing 2 and which has three coaxial walls 7 provided with slots 8 (see Fig. 2) of the same type as slots 6 in walls 5 of the rotor. In the depicted embodiment in which the rotor includes two cylindrical walls, the integral stator has three walls encircling or positioned between the walls of the rotor, but the number of said slots carrying walls may obviously be larger or smaller, provided the walls of the rotor and the stator be alternately positioned at a very short distance.

A supply conduit 9 is connected with housing 2 of the intensive mixer and communicates with a source (not shown) for lipid component with a substantial content of crystalline fat as explained above. Said source may for instance be a positive pressure pump supplying conventional butter directly from a butter machine or churn at a temperature approximately at 15°C.

Supply conduit 9 accommodates a pipe 10 for injecting the aqueous component, having a number of perforations 11 distributed throughout the length of the pipe. Pipe 10 is connected with a source (not shown) for the supply of the aqueous component under pressure.

During operation of the apparatus for carrying out the process of the invention rotor 4 is made to rotate, e.g. at a velocity of some 1000 rpm. The lipid component, e.g. conventional butter at 15°C, is pumped through supply conduit 9 so as to flow along the external surface of pipe 10, closely passing the perforations 11.

The aqueous component is pressed through said perforations, thereby forming cavities filled with the

aqueous component in the passing flow of the lipid component.

The flow of lipid component in which the aqueous component is now coarsely distributed passes further to fill the interior of housing 2, from which it passes through slots 8 in the innermost of the integral stator walls 7. Immediately after the flow has passed through the slots in said innermost wall it reaches the innermost of the quickly rotating walls 5 with sharp-edged slots 6. It is thereby exposed to strongly displacing and shearing forces and this is repeated when pressed or hurled further into the slots in the central stator wall and further on to the slots in the external rotor walls, and finally therefrom to the slots in the external stator wall. After the flow has so passed through the stator and rotor slots the aqueous component has been effectively emulsified as small droplets uniformly distributed in the lipid component and the product leaves the apparatus through a discharge 12, ready to be packaged.

The use of a particular pipe 10 injecting the aqueous component into the lipid component prior to reaching the mixing zone has turned out to be absolutely necessary, since if such member is not used, e.g. if the aqueous component is merely pumped through a branch of supply conduit 9, at least part of the aqueous component will not be properly emulsified in the lipid component when passing through the mixing zone formed by the rotor and stator walls.

The invention will now be elucidated in detail by the following examples.

EXAMPLES

In the following examples the process according to the invention was carried out by use of an apparatus

as illustrated in Figures 1 and 2. In all experiments the rotor was driven at a velocity of 2800 rpm.

As the lipid component all examples made use of conventional butter of the following approximate composition:

Butter fat	82% by weight
Water	16% by weight
Non fat solids	2% by weight

At a temperature approximately at 15°C the butter was pumped through the supply conduit of the mixing apparatus and during its passage therethrough the aqueous component was being pumped through the perforated pipe 10 at a temperature approximately at 12°C.

The composition of the aqueous component in each individual example and the composition of the resulting products appear from the following Table:

TABLE

	1	2	3	4	5
Composition of aqueous component, % by weight:					
Water	100				
Buttermilk		100	90	82	88
Skimmilk powder			10		
Buttermilk powder				8	12
End products composition, % by weight:					
Butter fat	68.0	44	48	50	62
Butter fat Water	30.06	50.73	44	41.77	32.25
Non fat solids	1.94	5.27	7.98	8.23	5.75

All these products were stable and had good keeping qualities without liberating droplets of the aqueous phase which is otherwise a frequent defect of butter and margarine products with a low fat content. From an organoleptical point of view the products were extremely satisfactory.

It should be observed that the results of the examples given in the preceding Table should not be regarded as an expression of what can be achieved by optimizing the process, the indicated water content of the end product should not be taken as an indication of the maximum water content allowable when stable end products are to be obtained.

PATENT CLAIMS

1. A process for producing a solid water-in-oil emulsion, such as butter or margarine, having a water content exceeding 30%, from an aqueous component and a lipid component, in which said lipid component is passed once through a mixing zone, comprising distributing by injection at several sites mutually spaced apart upstream of said mixing zone into a flow of the lipid component at a temperature at which a substantial portion of the fatty substance of the lipid component is in a crystalline state, the aqueous component at a temperature not exceeding the temperature which would cause said portion of the fatty substance of the lipid component that is in a crystalline state to leave this state, following which the flow of the lipid component, into which the aqueous component has been injected, is subjected to an intensive mixing under conditions particularly involving displacing and shearing forces, characterized in using as the aqueous component buttermilk, skimmilk or water without the addition of emulsifiers or lactic acid and in taking provisions that the temperature of the emulsion by the intensive mixing does not rise to such a temperature at which the fatty substance would leave the crystalline state.

2. A process as claimed in claim 1, characterized in using as the lipid component butter with a water content in the range from 12 to 23% by weight.

3. A process as claimed in claims 1 or 2, characterized in that prior to the injection of the aqueous component into the lipid component and the subsequent intensive mixing, provision is made that the temperature of both components be ranging between 10 and 20°C.

4. A process as claimed in claim 3, characterized in that the temperature of the lipid component is approximately at 15°C and the temperature of the aqueous component is approximately at 13°C.

5. An apparatus for carrying out the process according to any of the preceding claims, comprising an intensive mixer (1) in which the material to be processed is passed through slots (6, 8) in closely adjacent walls (5, 7) having a high mutual velocity difference in a direction transverse to the direction of the slots, and a supply conduit (9) to the mixer for a flow of lipid component, the fat of which substantially occurs in a crystalline state, and mounted coaxilly within the supply conduit (9) at least one pipe (10) provided with perforations (11), said pipe being connected with a source for aqueous component, for injecting the aqueous component into various spots spaced apart in the flow of lipid component during its flowing through the supply conduit.

6. An apparatus as claimed in claim 5, characterized in that the intensive mixer includes a rotor (4) with cylindrical walls (5) coaxial with the rotor and provided with sharp-edged slots (6) obtained by drilling away sections of the walls in the axial direction thereof, and a stator with cylindrical walls (7) in engagement with the rotor and which in a similar manner as the walls of the rotor have slots (8) drilled in the axial direction, said walls (7) extending with poor clearance in parallel to and between and completely or partially encapsulating the walls (5) of the rotor.

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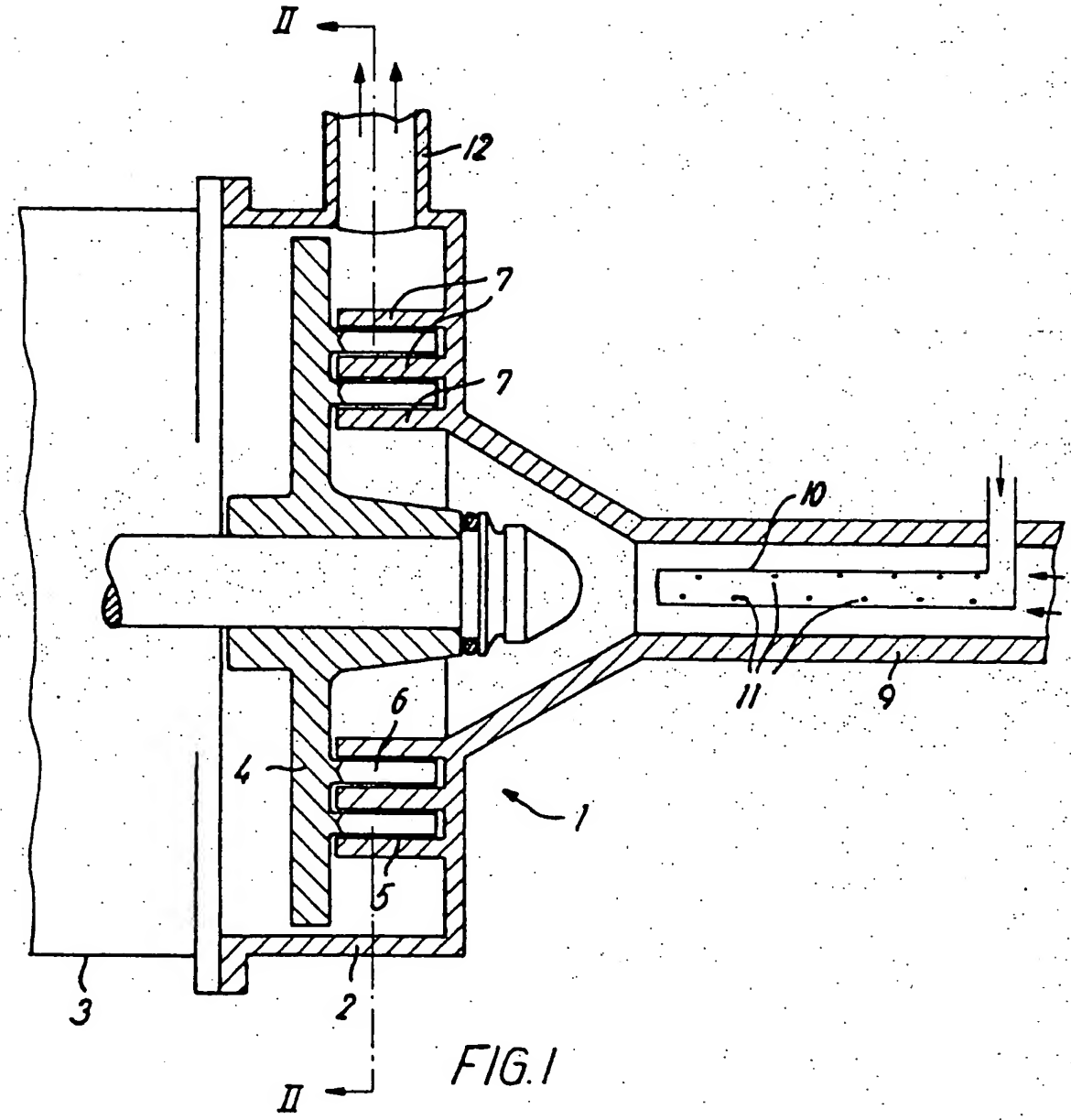

FIG.1

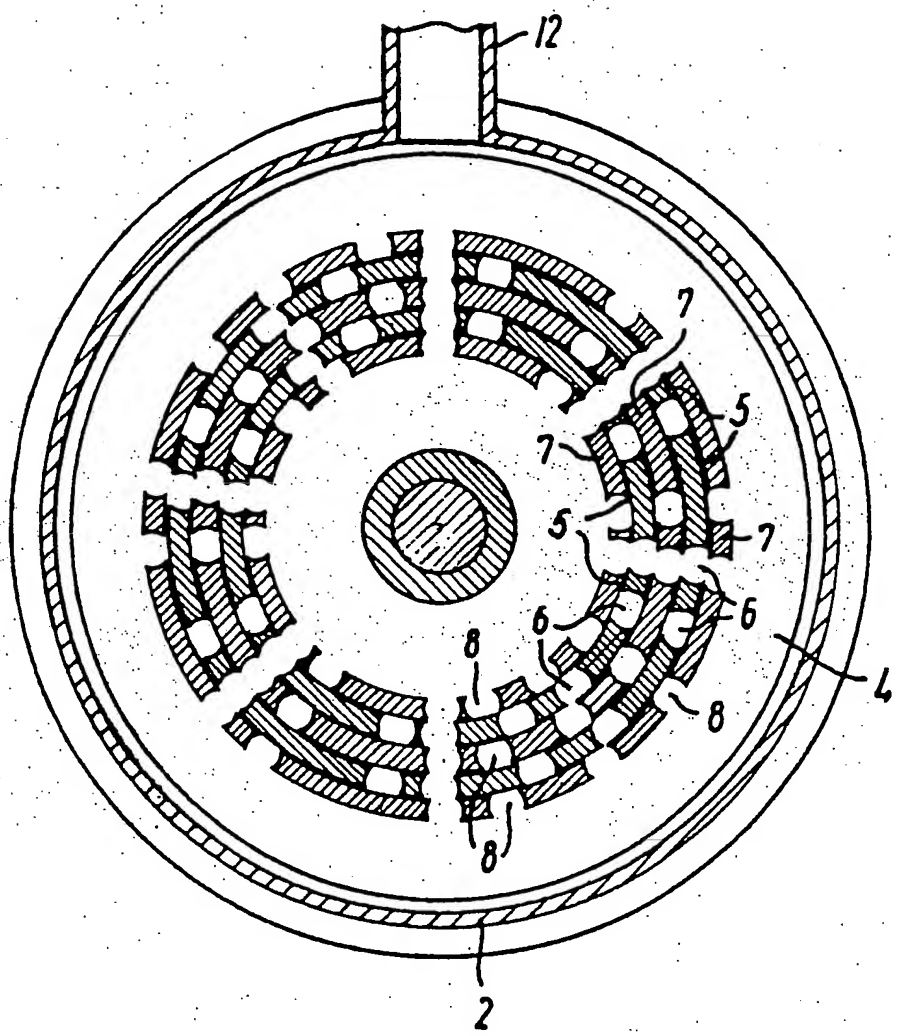

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 91/00376

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 A23C15/16; A23D7/00; A01J17/00; B01F7/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	A23C ; A23D ; B01F ; A01J

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
A	JOURNAL OF DAIRY SCIENCE. vol. 54, no. 12, 1971, CHAPAIGN, ILLINOIS US pages 1801 - 1806; D.H.BULLOCK ET AL.: 'Continuous manufacture of a low-fat dairy spread having a water-in-fat emulsion' see page 1801, column 2 - page 1803, column 1 - see page 1805, column 2	1-3
A	GB,A,1 094 268 (UNILEVER) 6 December 1967 see example 9	1,3
A	FR,A,1 351 868 (UNILEVER) 30 December 1963 see claims 1,10; examples 4,6	1,3,4
A	EP,A,0 101 104 (UNILEVER) 22 February 1984 see claim 1; figure 1; example 2	1,4

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° Special categories of cited documents : [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
11 AUGUST 1992	17. 09 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	DESMEDT G.R.A.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

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A	FR,A,2 319 300 (SOC. D'ASSISTANCE TECHNIQUE POUR PRODUITS NESTLE) 25 February 1977 cited in the application see claims 1-17; example 1A	1,4
A	FR,A,1 033 334 (H.HANSEN) 9 July 1953 see page 1, column 2 - page 2, column 1; claims 1-4; figures 1,2	5-6
A	FR,A,1 512 334 (FARBENFABRIKEN BAYER A.G.) 9 February 1968 see page 1, column 2 - page 2, column 1; claim 1; figure	5
A	WO,A,8 001 497 (SREDNEAZIATSKY NAUCHNO-ISSLEDOVATELSKY INSTITUT PRIRODNOGO GAZA) 24 July 1980 see figures 1,2	5,6
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A	US,A,2 605 185 (S.BJARNE ET AL.) 29 July 1952 see column 5, line 1 - line 18; claim 1	1,3

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. DK 9100376 SA 55414

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 11/08/92
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